Cohesive Aggregation of Dust in Parabolic Flight Experiments. A. Whizin[1], D. Durda[2], C. Tsang[2], and S. Love[3], [1]University of Central Florida, [2]Southwest Research Institute, [3]NASA JSC. (email:awhizin@knights.ucf.edu)

Introduction: The fundamental mechanical properties of the dust that makes up protoplanetesimals in the solar nebula are critical to understand if we are to inform accretion hypotheses regarding early stage terrestrial planet formation [1]. The mineralogy of this dust is similar to the surfaces of primitive asteroids and comets and it's critical to exploration science to characterize properties such as cohesion, aggregation, porosity, and coefficient of restitution in order to better inform the design and operation of spacecraft and ISRU technology. The objective of the experiments is to determine the effects of particle size, number density, and composition on the accretion of dust-scale grains in microgravity conditions.

We are designing a parabolic flight experiment to study the dependence of fundamental properties of different relevant analog minerals on the growth of porous clusters (aggregates) in microgravity. Our dust aggregation experiments are a follow-up to free-float experiments initially performed by astronaut Don Pettit aboard the ISS like the one shown in Figure 1 [2], and later performed by co-author Dr. Durda. In the Pettit experiments bags of finely grained materials like coffee and sugar were agitated and left to free-float immediately showing the aggregation of the highly cohesive materials. The clusters that formed did so due to surface forces such as van der Waals electrostatic forces. In a low-gravity environment these and other secondary forces dominate over the self-gravity of the cluster; this is the case in the nascent protoplanetary disk where small mm to cm-sized protoplanetesimals first form.

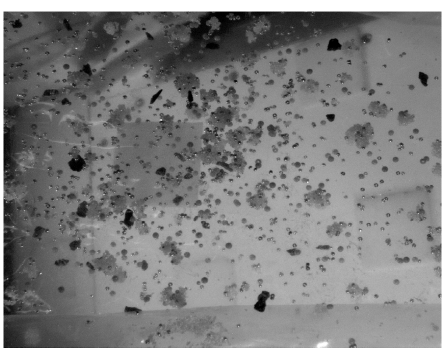

Figure 1: Aggregates and individual particles of sugar and other materials that were allowed to float for several hours aboard the ISS (Figure from Love et al 2014).

Experiment: In our experiment we take several cubic Plexiglas boxes with attached HD cameras each filled with different minerals or mixtures of minerals aboard a Zero-G parabolic aircraft (Figure 2). During each parabola a single box is removed from the storage case and allowed to free-float for the ~20 seconds of microgravity. Experiments on the ground and aboard the ISS have shown that this is more than enough time to allow for the rapid formation of aggregates of the dust [3]. The formation and subsequent collisions of the aggregates will be films via two cameras set 90 degrees apart to facilitate a 3D rendering of the aggregates shape, size, and velocity for later analysis.

Advance tracking software will be used to track the particles and clusters. Determining the shape and the volume of the aggregate leads to calculations of its density and bulk porosity. The data of this prior to and after a collision with a wall will give us the compaction of the aggregates, an important source of energy loss in collisions that can aid in the sticking (accretion) of porous clusters and an extremely underrepresented process in the literature.

We will use sieved olivines and pyroxenes of the correct mineral phase as nebular analogs; these are also minerals that are present on nearly every small body and many planetary surfaces. We will also use available funds to acquire and use ground ordinary and carbonaceous chondrite meteorites for realistic analog materials.

References: [1] Blum and Wurm 2008; [2] Love et al 2014; [3] Poppe and Schräpler 2005.

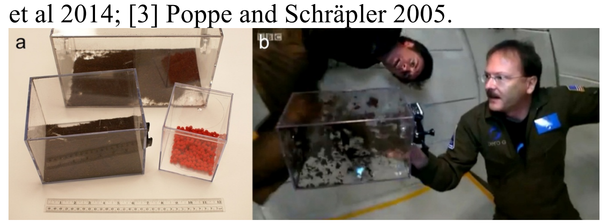

Figure 2: Examples of (a) the Plexiglas boxes that will be used to contain the free floating dust, and (b) co-author Dr. Durda flying a similar experiment on a parabolic aircraft.